Characteristics of Environment Factors in Secondary Poplar-Birch Forests after Mutual-Belt Selective Cutting

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Abstract The mutual-belt selective cutting was conducted in the secondary poplar-birch forests. The changes of environmental factors after cutting were observed. The environmental factors of effect belts(cutting belts) of 15 m in width had great changes. 10-m effect belts had unnoticed changes in environmental factors. The reserved belts with 10-m effect belts had a greater increase in DBH growth rate and volume growth rate. The reserved belts for 6-m and 8-m effect belts had lower increase in DBH and volume. The environmental factors of 6-m and 8-m effect belts did not change much, comparing with their reserved belts. Cluster analysis and principal component analysis for environmental factors between each two belts were also made, and the results proved that 10-m cutting belt is the best way for management of the secondary poplar-birch forests.

Key words: Environment factor, Belt cutting, Secondary poplar-birch forests, Effect-belt, Reserved-belt.

Introduction

Secondary poplar-birch forests widely distributed in forest region of Northeastern China. It was the pioneer community towards the climax vegetation, and was formed from the original broad-leaf pine forests which had been exploited and destroyed.

The experimental plot is located in the Zhangguangcai Mountains(N 45°22', E 129°25'). The research area was about 330 hm^2. In the experimental site, secondary poplar-birch forests was middle-young aged forests and lack of coniferous and hardwood trees. Poplar and birch make up 41.6% of stand composition, and coniferous trees only account for 12.3%. Valuable hardwood trees were below 21% of the stands. In order to improve stand quality and growth rate, we designed the mutual-belt selective cutting and observed the changes of environmental factors after the exploitation. This study aimed at providing theoretical basis for the management of secondary poplar-birch forests.

Research Methods

In this experiment, four management areas were set up. The first area was designed for 6-m, 8-m, and 10-m effect-belts(cutting belts) with 10-m reserved belts. The coniferous and valuable broad-leaf trees in cutting belts were reserved. The second area was designed as 10-m wide effect belts of and 10-m reserved belts. The third area was arranged for 15-m effect belts with 15-m reserved belts. The forth area was open lands in the forests. The cutting intensity for the first three areas was all 30%. Seven types of belts (including open land) were built up.

The observation of environmental factors was made every ten days during the growth period from May to September in 1991-92. The environmental factors observed includes light intensity, air temperature, air relative humidity, ground temperature and underground temperature(40 cm depth).

Single factor multilateral comparing analysis, cluster analysis and principal component analysis were used in the study.

Results and Analyses

Observation results

Five indexes of the environmental factors and their relative values were obtained by field observation. After belt-cutting, the greatest change was light intensity in both effect belts and reserved belts).The light intensity in the reserved belts, 6-m and 8-m effect belts, 10-m effect belts, 15-m effect-belts were 18%, 30-35%, 50% and 70%, respectively. The greater change was the ground temperature. The ground temperatur of effect-belts and reserved belts take up only 10.20% of that of open land. The minimum change was air temperature and air humidity. They were 10% lower than that in open

land(Table 1).

Table 1. The observing results of environment factors in the exploitation belts.

Environment factors		Researved belts		Effect belts				Open land
		10-m width	15-m width	6-m width	8-m width	10-m width	15-m width	
Light intensity	Average value	104.15	95.80	173.85	193.05	297.10	395.00	553.65
	Relative value (%)	18.81	17.30	31.40	34.87	50.41	71.34	100
Air relative humidity	Average value	94.4	94.3	92.8	92.0	91.3	91.2	82.7
	Relative value (%)	114.2	114.0	111.0	111.2	110.4	112.7	100
Air temperature	Average value	21.7	21.0	22.4	22.5	22.6	23.5	23.9
	Relative value (%)	90.92	87.99	93.85	94.27	94.69	90.08	100
Ground Temperature	Average value	21.7	22.7	22.4	23.7	24.8	27.6	31.7
	Relative value (%)	68.53	71.68	70.74	74.84	78.32	87.16	100
Underground temperature	Average value	13.3	13.31	14.1	14.3	14.8	14.8	18.7
	Relative value (%)	71.25	70.18	75.54	76.61	79.29	79.29	100

Differential comparison

The differential comparison between each two belts was made througth single factor multilateral comparing analysis. When the differential value is greater than 4.17($Q_{0.05}$=4.17), the differential degree between two belts is remarkable, noted it as "*", and when the value is greater than 4.88($Q_{0.01}$=4.88), it indicates that the differential degree between these two belts is very remarkable, and noted it as "**". The results of differential inspection of each factor between each belt are listed in Table 2 to 6.

Table 2. The differential inspection of light intensity

Belt type	15-m RB	6-m EB	8-m EB	10-m EB	15-m EB	open land
10mRB	0.3791	1.9333	2.5663	5.5305**	8.3545**	14.0863**
15m RB		2.3125	2.9454	5.9096**	8.7336**	14.4654**
6m-EB			0.6330	3.5972	6.4212**	12.1530**
8m-EB				2.9642	5.7882**	11.5200**
10m-EB					2.8240	8.5558**
15m-EB						5.7318**

Note. RB--Resetved belt , EB-Effect belt

Table 3. Differential inspection of air relative humidity

Belt type	15m-RB	6m-EB	8m-EB	10m-EB	15m-EB	open land
10m-RB	0.2969	1.9297	2.0782	2.4492	8.7420**	707190**
15m-RB		1.6329	1.7813	2.1524	4.4453*	7.4221**
6m-EB			0.1484	0.5195	1.1875	5.7892**
8m-EB				0.3711	1.3360	5.6408**
10m-EB					1.7071	5.2597**
15m-EB						5.9767**

Table 4. The differential inspection of air temperature

Belt type	15m-RB	6m-EB	8m-EB	10m-EB	15m-EB	open land
10m-RB	1.1516	0.7677	0.9247	1.1516	0.8724	3.1204
15m-RB		1.9193	2.0763	2.3031	0.2792	4.3620*
6m-EB			0.1570	0.3839	1.6401	2.4427
8m-EB				0.2268	1.7971	2.2857
10m-EB					2.0240	2.0589
15m-EB						4.0828

Table 5. Differential inspection of ground temperature

Belt type	15m-RB	6m-EB	8m-EB	10m-EB	15m-EB	open land
10m-RB	0.2026	0.7325	0.8883	2.0571	2.1350	7.1220**
15m-RB		0.9350	1.0909	2.2597	2.3376	7.3245**
6m-EB			0.1558	1.3247	1.4026	6.3895**
8m-EB				1.1688	1.2467	6.2337**
10m-EB					0.0779	5.0648**
15m-EB						4.9869**

Table 6.The differential inspection of underground temperature

Belt type	15m-RB	6m-EB	8m-EB	10m-EB	15m-EB	open land
10m-RB	0.8777	0.5778	1.7700	2.7428	5.1747**	9.7095**
15m-RB		0.2999	0.8923	1.8651	4.2970*	8.1318**
6m-EB			1.1922	2.1650	4.5969*	9.1317**
8m-EB				0.9728	3.4047	7.9395**
10m-EB					2.4319	6.9667**
15m-EB						4.8948**

Based on results from differential inspection, we can make up conclusions: The light intensity in each belt made great changes. The change of light intensity in open land was very remarkable, compared with other belts. The changes of light intensity in each effect belt were very remarkable, compared with 15-m and10-m reserved belts. The change of air temperature in open land was very remarkable, compared to 15-m effect belt. The change of air humidity in open land was very. remarkable , compared with other belts. 15-m effect belt made very remarkable change in air humidity, compared with 10-m reserved belts. Only open land had very remarkable change in underground temperature, compared with other belts. Open land also made very remarkable change in ground temperture, compared with other 6 belts. The difference in ground temperture be tween 15-m effect belts and 10-m reserved belts was very remarkable.

Synthesizing all above differential inspections of 5 environmental factors, we saw that light intensity and ground temperature in 15-m effect belts are very different from 6-m and 8-m effect belts. This demonstrated that 15-m effect belts had great change in the environmental condition. 10-m effect belts had very remarkable difference in light intensity with 2 reserved belts, but there were no remarkable change in other factors. This proved that 10-m belt cutting was the optimum cutting intensity, which did not resulted in the great change of environmental factors except that the light intensity was increased.

Principal component analysis(PCA)

Based on data in Table 1, we carried out the principal component analysis. The results(in Table 7-9) showed that: The relatedness between air temperature and light intensity or ground temperature were 64%-69%. The other relatedness were all above 80%. The relatedness between light intensity and ground temperature was 98%. Judged by the eigenvectors and contribution rates of each principal component, we can see that the contribution rate of the first principal component reaches 88.89% and the first two principal components reaches 99.9% .

Table 7. The correlation matrix of environmental factor

	X_1	X_2	X_3	X_4	X_5
X_1	1.0000	-0.8264	0.6863	0.9825	0.9809
X_2		1.0000	-0.9136	-0.8374	-0.9731
X_3			1.0000	0.6432	0.8612
X_4				1.0000	0.9339
X_5					1.0000

X_1--Light intensity; X_2--Air relative humidity; X_3--Air temperature

X_4- Ground temperature; X_5--Underground temperature

Judged by the loaded values of factors of each principal component, we can conclude that the factors of the greatest loaded value of the first principal component are underground temperature, air relative humidity and light intensity. This shows that these three factors are very important. They are dominant factors.

Table 8.The eigenvector values of principal components

Environment Factors	Y_1	Y_2	Y_3	Y_4	Y_5
X_1	0.4465	0.4423	0.5198	0.5618	0.1385
X_2	-0.4580	0.2907	-0.6328	-0.3436	-0.4327
X_3	-0.4118	-0.6864	0.5179	-0.2881	0.0893
X4	0.4440	0.4986	-0.1197	-0.6941	0.2410
X_5	0.4734	-0.0065	-0.2162	0.0392	-0.8530
Latent roots	4.4444	0.4856	0.0644	0.0046	0.0011
Contribution rate (%)	88.8874	9.7118	1.2872	0.0912	0.0224
Accumulative Contribution rate (%)	88.8874	98.5992	99.8864	99.9776	100.00

Table 9. The loaded values of environmental factors

Environment factors	Y_1	Y_2	Y_3	Y_4	Y_5
X_1	0.9414	-0.3082	0.1319	0.0397	0.0046
X_2	0.9556	0.2026	0.1605	-0.0232	-0.0145
X_3	0.8681	-0.4783	0.1314	-0.0195	0.0030
X_4	0.9360	0.3475	-0.0304	-0.0469	0.0081
X_5	0.9981	-0.0045	-0.0548	0.0026	-0.0286

Table 10. The first three principlal components coordinates of each observing belt

Belt number	Observing belt	Y_1	Y_2	Y_3
1	10 m-RB	-1.8850	-0.2688	-0.0155
2	15 m-RB	-2.1464	0.2008	-0.4864
3	6m-EB	-0.7218	-0.7196	0.0656
4	8m-EB	-0.4146	-0.5320	0.1512
5	10m-EB	0.2512	-0.2552	0.2779
6	15m-EB	0.2101	1.5106	0.2372
7	Open land	4.7064	-0.1359	-0.2301

Table.11 The Changes of DBH and volume after belt-cutting improvement

	Control plot	Convention plot	Belt-cutting plot				
			6 m	8 m	10 m	15 m	Average
DBH growth rate (%)	3.0376	3.9415	4.1508	4.3642	4.4961	3.4129	4.1060
Volume growth rate(%)	7.3544	9.0760	9.1021	10.1029	10.3981	8.0212	9.4061

Ordination analysis and cluster analysis

Based on the principal component analysis and their first three or first two principal components , we carried out ordination analysis and cluster analysis: Ordination analysis showed that point 6(15-m effect belt) and point 7 (open land) were obviously deviated, meanwhile, the other points(other belts) gathered around the zero point, and point 5 (10-m effect belt) located centrally(Fig.2). Cluster analysis showed that if it is classified by Y_1 principal component coordinate, all belts will divided into 4 groups: 10-m and 15-m effect belts; 6-m and 8-m effect belts; 10-m and 15-m reserved belts; and open land .If it is classified by Y_1 and Y_2 principal component coordinates, all belts will be resulted as Fig. 2. They are divided into 3 groups:10-m and 15-m reserved belts; 6-m, 8-m and 10-m effect belts; 15-m

effect belts and open land. And if it is classified by Y_1, Y_2 and Y_3 principal component coordinates, the clustering result are basically same as that classified by Y_1 and Y_2, but there will be a relative distance between reserved belts(15-m and 10-m) and effect belts(6-m, 8-m and 10-m).

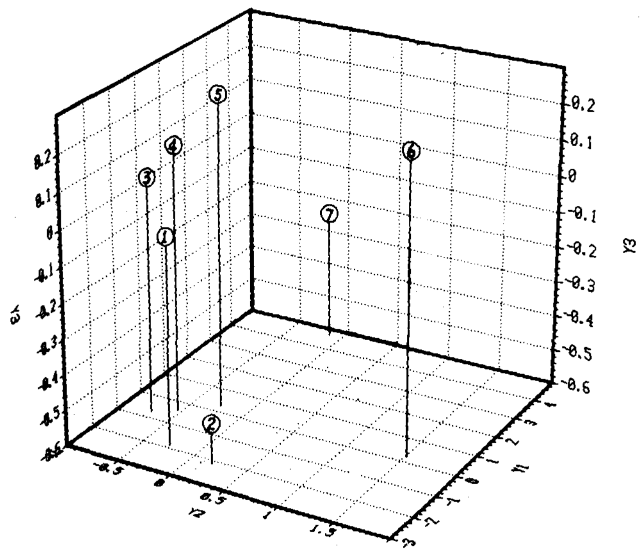

Fig. 1. Three dimensional ordination of observing belts

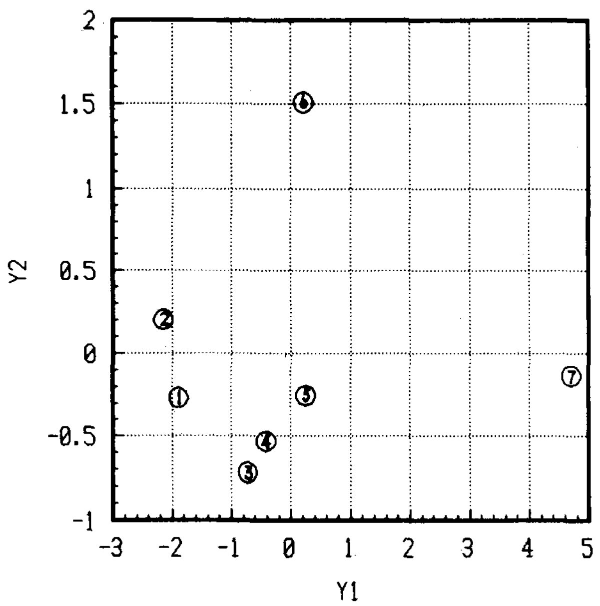

Fig. 2. Two dimensional ordination and classifying pictureof observing belts.

Conclusions

Single factor multilateral comparing analysis showed that all belts had very remarkable difference with open land. 15-m effect belts had very remarkable change in light intensity, compared with 2 reserved belts and 6-m, 8-m effect belts. 10-m reserved belts had remarkable difference in air relative humidity and ground temperature with 15-m reserved belts and 6-m effect belts. The light intensity of 10-m effect belts had very remarkable difference with 2 reserved belts and open land. These proved that 10-m belt cutting is the best way for management of secondary poplar-birch forests.

Stand growth survey also proved that the DBH growth rate and volume growth rate in the reserved belts of 10-m effect belts were higher than that of 6-m, 8-m and 15-m effect belts.

Analysis results accorded with edge-effect theory. In the secondary Poplar-birch forests, 6-m and 8-m effect belts are relatively narrow so that edge-effect was not notable. 15-m effect belts are too wide and edge positive effect will decrease by reducing effective edge-area. The optimum width for effect belt is 10 meter in secondary Poplar-birch forests.

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(**Responsible Editor**: Chai Ruihai)